DATA QUALITY SUMMARY REPORT FOR NEPHELOMETER B_{SP} DATA COLLECTED BY SONOMA TECHNOLOGY, INC., DURING THE CALIFORNIA REGIONAL $PM_{10}/PM_{2.5}$ AIR QUALITY STUDY

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1. INTRODUCTION AND OBJECTIVES

The purpose of this Data Quality Summary Report is to provide data users with an understanding of the quality of nephelometer data collected by Sonoma Technology, Inc. (STI) for the California Regional PM_{10}/$PM_{2.5}$ Air Quality Study (CRPAQS). **Table I-1** summarizes the operating sites and times for nephelometer measurements during CRPAQS. The nephelometer measured the light extinction coefficient from scattering by particles (b_{sp}) on a 5-minute basis in Mm^{-1}. These digital data were then averaged to 60-minute values; both 5-minute and 60-minute values were reported in the corresponding database and reports. This report provides summary information on data completeness, lower quantifiable limit (LQL), accuracy, and precision. Data completeness was calculated for each site based on data delivered to ARB; the start date/time indicates the beginning of valid data, continuous until the stop date/time. Data validation suggested that the nephelometer instruments performed similarly; thus, Angiola was used as a representative site to calculate LQL, accuracy, and precision for all nephelometer monitors operated by STI in the study.

As Table I-1 indicates, valid nephelometer data from the Angiola Trailer started on February 1, 2000; however, this instrument began operation at Angiola in December 1999. The data reported from December 1999 until February 1, 2000, were not of sufficient quality to deliver to ARB. In addition, for all sites, 1-minute analog data (if available) were used to fill digital data gaps larger than 12 hours. For more information please reference the quality control screening procedures documented by Hafner et al. (2003).

Table I-1. Location and duration of nephelometer measurements made by STI during CRPAQS.

Site	Start Date/Time	Stop Date/Time
Angiola Trailer	2/1/00 14:00 PST	2/9/01 23:55 PST
Angiola 1-m Tower	12/14/00 19:45 PST	2/9/01 23:55 PST
Angiola 50-m Tower	8/18/00 13:20 PST	2/9/01 23:55 PST
Angiola 100-m Tower	8/18/00 0:00 PST	2/9/01 23:55 PST
Bakersfield	1/6/00 17:10 PST	2/9/01 23:55 PST
Sacramento Del Paso	12/24/99 23:00 PST	2/9/01 23:55 PST
San Jose	2/3/00 18:45 PST	2/9/01 23:55 PST
Walnut Grove Tower	11/26/00 16:15 PST	2/9/01 23:55 PST

Several other documents are available from which to obtain information about the CRPAQS field study and data processing. Sampling locations are described in Wittig et al. (2003). Quality control screening procedures are summarized by Hafner et al. (2003). Results of systems and performance audits and intercomparisons are provided by Bush et al. (2001).

The data quality objectives (DQOs) for the nephelometer from the instrument specifications are shown in **Table I-2**. DQOs for data completeness, accuracy, and precision were not available. Both the 5-minute and 60-minute data met the LQL DQO.

Table I-2. Data quality objectives for nephelometer data collected during CRPAQS.

Data Quality Metric	Objective
Lower Quantifiable Limit	$< 1\ Mm^{-1}$

2. DATA COMPLETENESS

Data completeness for 5-minute and 60-minute nephelometer b_{sp} is shown in **Table I-3**. Data capture quantifies the percentage of total records received versus the number expected during the "period of operation" defined by the start and stop dates/times in Table I-1; the start date/time is the first instance of valid data, and the period of operation is continuous until the stop date/time. The number of valid data points is divided by the number of captured data points to calculate the data recovery. Validity is defined for this calculation as any data point that has a quality control flag of V0 (valid) or V1 (valid but comprised wholly or partially of below-MDL data). Details of data validation are included in Hafner et al. (2003).

Table I-3. Data completeness values for b_{sp} at each site.

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Monitoring Site	Total No. of Records	Expected No. of Records	Percent Capture[a]	Valid No. of Records	Percent Recovery[b]	No. of Suspect Records	No. of Invalid Records	No. of Missing Records
Angiola Trailer (5-min)	107,832	107,832	100%	102,952	95%	1182	568	3130
Angiola Trailer (60-min)	8986	8986	100%	8584	96%	87	82	233
Angiola 1-m Tower (5-min)	16,467	16,467	100%	11,233	68%	3284	1415	535
Angiola 1-m Tower (60-min)	1373	1373	100%	950	69%	222	165	36
Angiola 50-m Tower (5-min)	50,528	50,528	100%	0	0%	39,277	8244	3007
Angiola 50-m Tower (60-min)	4211	4211	100%	0	0%	3254	720	237

Table I-3. Data completeness values for b_{sp} at each site.

Monitoring Site	Total No. of Records	Expected No. of Records	Percent Capture[a]	Valid No. of Records	Percent Recovery[b]	No. of Suspect Records	No. of Invalid Records	No. of Missing Records
Angiola 100-m Tower (5-min)	50,688	50,688	100%	0	0%	40,457	8606	1625
Angiola 100-m Tower (60-min)	4224	4224	100%	0	0%	3337	765	122
Bakersfield (5-min)	115,282	115,282	100%	108,752	94%	2602	2291	1637
Bakersfield (60-min)	9607	9607	100%	9064	94%	191	234	118
Sacramento Del Paso (5-min)	118,956	118,956	100%	91,886	77%	5063	5538	16,469
Sacramento Del Paso (60-min)	9913	9913	100%	7650	77%	403	522	1338
San Jose (5-min)	107,199	107,199	100%	105,238	98%	745	260	956
San Jose (60-min)	8934	8934	100%	8772	98%	53	40	69
Walnut Grove Tower (5-min)	21,693	21,693	100%	20,154	93%	811	135	593
Walnut Grove Tower (60-min)	1808	1808	100%	1673	93%	56	31	48

[a] % capture = total number of records/expected records*100%.
[b] % recovery = number of valid records/total number of records.

All sites had a 100% data capture rate. Except for the Angiola 50-m and 100-m towers, data recovery rates ranged from 68% (Angiola 1-m tower) to 98% (San Jose). In comparisons described in Hafner et al. (2003), the Angiola 50-m and 100-m tower b_{sp} data compared poorly to the trailer and 1-m tower data during side-by-side tests; all the 50-m and 100-m tower data were flagged as suspect.

3. LOWER QUANTIFIABLE LIMIT

The LQL is the lowest concentration in ambient air that can be measured when processing actual samples. Sources of variability that influence the monitored signal at low concentrations include instrument noise and atmospheric variability. As a measure of this variability, two times the standard deviation of selected 5-minute and 60-minute b_{sp} data were used to estimate the LQL. The selected data were collected during relatively stable periods with concentrations close to background levels. This is a conservative estimate of the LQL because it includes the concentration variability of the ambient air. Twelve consecutive data values were used to compute the LQL with the 5-minute data and six data values with the 60-minute data; atmospheric variation generally becomes too great after six hours to calculate a reasonable LQL. Since only half the number of data values were used in the calculation (see "N" in Equation I-1), the 60-minute LQL is expected to be higher than the 5-minute LQL, despite the "smoothing" that occurs when averaging 5-minute to 60-minute values.

Table I-4 shows the 5-minute and 60-minute LQL, as well as the specific data strings used to calculate the LQL at the representative site Angiola. The LQL is calculated as shown in Equation I-1. The LQLs meet the DQO.

$$\mathrm{LQL} \approx 2s = 2\sqrt{\frac{\sum (b_{sp} - \bar{b}_{sp})^2}{N-1}} \qquad \textbf{(I-1)}$$

where:

$\bar{b}_{sp}$ = mean nephelometer b_{sp}
N = number of measurements
σ = standard deviation

Table I-4. Time period used to calculate LQL, the LQL, and the corresponding mean b_{sp} value during the selected time period at the representative site, Angiola.

Type of data	Time Period Used in LQL Calculation	LQL (Mm^{-1})	Mean (Mm^{-1})
5-minute	4/17/00 05:55 – 06:55 PST	0.254	1.68
60-minute	2/16/00 17:00 – 18:00 PST	0.513	2.02

4. ACCURACY

Accuracy for the nephelometer can be found by evaluating the deviation of measurements from a standard reference. This method quantifies the variability in the routine accuracy of the instrument by evaluating the calibration checks, which were performed periodically in CRPAQS.

Calibration checks were performed with both CO_2 and Freon 134a (SUVA). The nephelometer temperature and ambient pressure (manually set according to the site elevation when not measured by the nephelometer) were used to calculate the light-scattering coefficient of the span gas. Because the nephelometer is calibrated to read zero when filled with particle-free air, the correct b_{sp} reading during the span calibration is the scattering coefficient of the span gas minus the scattering coefficient of air. The spreadsheet calculated the ratio of the b_{sp} measured by the nephelometer during the span calibration to the expected value. These periodic checks can be used to evaluate the accuracy of the instrument throughout the study. Accuracy can be expressed in terms of the 95% confidence interval (CI). For nephelometer b_{sp} measurements by STI, the 95% CIs were calculated from the differences between monitor response and expected b_{sp} during the calibration checks. The 95% CI approximates the accuracy of the data as shown in Equation I-2.

$$\text{Accuracy} \approx 95\% \text{ confidence interval} = 1.96\left(\frac{s_{cal}}{\sqrt{N}}\right) \qquad \textbf{(I-2)}$$

where:

$$s_{cal} = \sqrt{\frac{\sum (x - \bar{x})^2}{N - 1}}$$

$$\mathrm{x} = [\mathrm{b}_{xp}]_{cal} - [\mathrm{b}_{xp}]_{measured}$$

$$\bar{\mathrm{x}} = \frac{\sum \left([\mathrm{b}_{xp}]_{cal} - [\mathrm{b}_{xp}]_{measured}\right)}{\mathrm{N}}$$

$[b_{xp}]_{cal} = b_{sp}$ expected during calibration

$[\mathrm{b}_{xp}]_{measured} = b_{sp}$ measured by the analyzer.

The 95% CIs and the number of calibration checks used to estimate the CIs for b_{sp} at Angiola are provided in **Table I-5** for both CO_2 and SUVA data.

Table I-5. Accuracy, b_{sp} of calibration gas, and number of calibration check data points used for the 5-minute b_{sp} at the representative site, Angiola.

Calibration Gas Type	Calibration Target b_{sp}	No. of Spans Used	Accuracy
CO_2	21 Mm^{-1}	15	0.52 Mm^{-1}
SUVA	83 Mm^{-1}	15	2.96 Mm^{-1}

5. PRECISION

The consistency of the periodic calibrations provides a measure of precision in the nephelometer b_{sp} measurements. The precision was evaluated by comparing the measured b_{sp} during the calibration to the average measured b_{sp} during calibrations for the entire study. The CI at a 95% confidence limit of the span measurements was used to estimate the precision of the data as shown in Equation I-3. This is applicable to both 5-minute and 60-minute data.

$$\text{Absolute Precision} \approx \text{CL} = 1.96 \times \frac{\sigma_{measured}}{\sqrt{\mathrm{N}}} \qquad \textbf{(I-3)}$$

where:

$$\sigma_{\text{measured}} = \sqrt{\frac{\sum\left([b_{sp}]_{\text{measured}} - [\bar{b}_{sp}]_{\text{measured}}\right)^2}{N-1}}$$

All the nephelometer b_{sp} values in Equation I-3 refer to the values measured during the calibrations. **Table I-6** shows the precision calculated for the representative site, Angiola.

Table I-6. Precision, b_{sp} of calibration gas, and the number of calibration checks used to calculate the precision of the 5-minute b_{sp} data at the representative site, Angiola.

Calibration Gas Type	Calibration Target b_{sp}	No. of Calibrations Used	Precision
CO_2	21 Mm^{-1}	15	0.7 Mm^{-1}
SUVA	83 Mm^{-1}	15	3.8 Mm^{-1}

6. REFERENCES

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